

## 1 Selected Ch 13 Problems

1. You are working on the plumbing system of a sky scraper. If you have a constant pipe area of  $.1m^2$ , what minimum pressure must your water pump, on the basement level, apply if you want to pump water up to the 95th floor, 300m up from the basement? Assume the pipe to be of constant area, thus constant pressure.

Ans) If we want to apply Bernoulli's equation we need to indentify each of the variables in it. Bernoulli's equation is

$$p_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = p_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$$

If the pressure in the pipe is constant, then we can assume that  $p_1$  and  $p_2$ , which are the pipe pressures at the top and bottom of the skyscraper, are equal and will cancel eachother out. Also, since we can set our coordinate system zero point wherever we want, we simply set it to zero in the basement, thus  $y_1 = 0$  and  $y_2 = 300m$ . Finally, we want to solve for  $v_1$  and can assume that if the water just barely makes it to the top then the final velocity  $v_2 = 0$ . Now, plugging in our numbers gives us a basic conservation of energy equation. Note that all the  $\rho$ 's cancel out.

$$\frac{1}{2} v_1^2 = (9.8m/s^2)(300m)$$
$$v_1 = 76.7m/s$$

2. One day, while sitting on an airplane, you wonder just how it stays "afloat." So, you decide to calculate the lift on the airplane's wings. Assume each wing has an area of  $4.00m^2$  and it is designed so the air flows over the top of the wing, while at cruising speed, at 245m/s and under the wing at 222m/s. The height difference between the top and bottom of the wing is 1m. The density of air is  $\rho = 1.29kg/m^3$ .

Ans) Using Bernoulli's equation and setting our coordinate system to zero at the bottom of the wing we have

$$p_1 + \rho g y_1 + \frac{1}{2} \rho v_1^2 = p_2 + \rho g y_2 + \frac{1}{2} \rho v_2^2$$
$$\Delta p = p_1 - p_2$$
$$\Delta p + \frac{1}{2} (1.29k/m^3)(222m/s)^2 = (1.29kg/m^3)(9.8m/s^2)(1m) + \frac{1}{2} (1.29kg/m^3)(245m/s)^2$$
$$\Delta p = 6940Pa$$
$$Force = Pressure * Area = 6940Pa * 4.00m^2 = 27700N \text{ or } 6200lbs$$

Multiply the answer by two to get the answer for both wings and you get the bouyant force on your plane is about 12000 lbs. You must be on a small plane because a 747 on takeoff is about 875000lbs.

3. Consider a raft floating in water. If the raft has a density of  $600kg/m^3$ ,

an area of  $5.7m^2$ , and a volume of  $V = .60m^3$ , find the height of the raft that is underwater.

Ans) If we draw the raft floating on the water the only forces are the bouyant force and the weight. If it is floating these forces equal out and therefore  $F_B - mg = 0$ . The bouyant force is given by the weight of the amount of water displaced, or  $F_B = m_{h2o}g = \rho_{h2o}V_{h2o}g = \rho_{h2o}Ahg$ . The weight can be found by  $mg = \rho_{raft}V_{raft}g$ . We can now solve for the height of the raft in the water.

$$\begin{aligned}\rho_{h2o}Ahg &= \rho_{raft}V_{raft}g \\ h &= \frac{\rho_{raft}V_{raft}}{\rho_{h2o}A} \\ h &= .063m\end{aligned}$$

4. Using the ideas from the previous problem, what percentage of an iceberg is underwater, if  $\rho_{saltwater} = 1025kg/m^3$  and  $\rho_{ice} = 917kg/m^3$ ?

Ans) We can modify the height equation from before to express the volume of the iceberg as its height times its area. Assuming the area is constant both above and below water we get

$$\begin{aligned}h_{inwater} &= \frac{\rho_{ice}h_{iceberg}}{\rho_{saltwater}} \\ \frac{h_{inwater}}{h_{iceberg}} &= \frac{\rho_{ice}}{\rho_{saltwater}} \Rightarrow .895\end{aligned}$$

Or about 90 percent of the iceberg is underwater.